

III. AMENDMENTS TO THE CLAIMS

Please amend Claim(s) 66 as follows.

1. (Original) A method for managing compression of pages of memory in a system comprising physical memory, wherein the physical memory comprises system memory, the method comprising:

receiving a system memory access;

locating a page translation entry for the system memory access in a page translation table;

determining if a page in the physical memory and referenced by the page translation entry is compressed or uncompressed;

if said determining indicates the page is compressed:

decompressing the compressed page to produce a decompressed page;

writing the decompressed page to the physical memory; and

providing a first physical memory address of the decompressed page in the physical memory to fulfill the system memory access.

2. (Original) The method of claim 1, further comprising:

if said determining indicates the page is uncompressed, providing a second physical memory address as indicated by the page translation entry to fulfill the system memory access.

3. (Original) The method of claim 1, further comprising:

if said determining indicates the page is uncompressed:

determining if the uncompressed page is to be compressed;

if said determining indicates the page is to be compressed:

compressing the uncompressed page to produce a compressed page; and

writing the compressed page to the physical memory.

4. (Original) The method of claim 3, wherein said compressing the uncompressed page comprises:

providing the uncompressed page to a compression engine; and

the compression engine compressing the page to produce the compressed page.

5. (Original) The method of claim 4, wherein said providing the page to the compression engine comprises:

a Direct Memory Access (DMA) channel reading the uncompressed page from the physical memory; and

the DMA channel writing the uncompressed page to the compression engine.

6. (Original) The method of claim 4, wherein said writing the compressed page to the physical memory comprises:

a Direct Memory Access (DMA) channel reading the compressed page from the compression engine; and

the DMA channel copying the compressed page into one or more linked compressed blocks in the physical memory.

7. (Original) The method of claim 6, further comprising locating the one or more linked compressed blocks for storing the compressed page in a list of available compressed blocks for storing compressed pages.

8. (Original) The method of claim 4, wherein said providing the page to the compression engine comprises:

a plurality of Direct Memory Access (DMA) channels reading the uncompressed page from the physical memory; and

the plurality of DMA channels writing the uncompressed page to the compression engine.

9. (Original) The method of claim 4, wherein said writing the compressed page to the physical memory comprises:

a plurality of Direct Memory Access (DMA) channels reading the compressed page from the compression engine; and

the plurality of DMA channels copying the compressed page into one or more linked compressed blocks in the physical memory.

10. (Original) The method of claim 3, wherein said compressing the uncompressed page comprises:

providing a different portion of the uncompressed page to each of a plurality of compression engines; and

the plurality of compression engines compressing the provided uncompressed portions of the page to produce compressed portions of the page.

11. (Original) The method of claim 10, wherein each of the plurality of compression engines implements a data compression algorithm, wherein the data compression algorithm is substantially the same for each of the plurality of compression engines.

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12. (Original) The method of claim 10, wherein the plurality of compression engines compresses the uncompressed portions of the compressed page in parallel.

13. (Original) The method of claim 10, further comprising combining the compressed portions of the page to produce the compressed page.

14. (Original) The method of claim 3, wherein said compressing the uncompressed page comprises:

providing the uncompressed page to a plurality of compression engines, wherein each of the plurality of compression engines implements a different compression algorithm;
the plurality of compression engines each compressing the uncompressed page using the compression algorithm implemented by the particular compression engine to produce a plurality of compressed pages compressed by different compression algorithms;
selecting the compressed page from the plurality of compressed pages, wherein the selected compressed page has the highest compression ratio of the plurality of compressed pages.

15. (Original) The method of claim 14, further comprising marking the page translation entry associated with the selected compressed page to indicate the particular compression algorithm used in said compressing the page.

16. (Original) The method of claim 14, wherein the plurality of compression engines compresses the page in parallel.

17. (Original) The method of claim 1, wherein one or more recently used page translation entries from the page translation table are cached in a page translation cache, and wherein said locating a page translation entry comprises:

searching for the page translation entry associated with the system memory address in the page translation cache;

wherein, if said searching locates the page translation entry in the page translation cache, the page translation entry from the page translation cache is used in said determining if the page is compressed or uncompressed.

18. (Original) The method of claim 17, wherein, if the page translation entry is not located in the page translation cache, the method further comprises searching for the page translation entry in the page translation table;

wherein, if said searching locates the page translation entry in the page translation table, the page translation entry from the page translation table is used in said determining if the page is compressed or uncompressed.

19. (Original) The method of claim 18, further comprising caching the page translation entry located in the page translation table to the page translation cache as a recently used page translation entry.

20. (Original) The method of claim 17, wherein the page translation cache comprises a plurality of page translation entries, and wherein the page translation cache is fully associative.

21. (Original) The method of claim 20, wherein said searching for the page translation entry associated with the system memory address in the page translation cache comprises comparing the system memory address with all page translation entries in the page translation cache in parallel.

22. (Original) The method of claim 1, wherein said decompressing the page comprises: providing the page to a decompression engine; and the decompression engine decompressing the page to produce the decompressed page.

23. (Original) The method of claim 22, further comprising, if said determining indicates the page is compressed:

prior to said providing the page to a decompression engine:

examining the page translation entry to determine a compression algorithm used to compress the page; and

selecting the decompression engine from a plurality of decompression engines, wherein the decompression engine is configured to decompress data compressed using the determined compression algorithm.

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24. (Original) The method of claim 22, wherein the decompression engine is a parallel decompression engine, wherein, in said decompressing the compressed page, the parallel decompression engine decompresses portions of the page in parallel.

25. (Original) The method of claim 22, wherein the page comprises one or more compressed blocks, and wherein said providing the page to the decompression engine comprises: a Direct Memory Access (DMA) channel reading the one or more compressed blocks; and the DMA channel copying the one or more compressed blocks to the decompression engine.

26. (Original) The method of claim 25, wherein the DMA channel reading the one or more compressed blocks comprises:

loading a physical memory address of a first compressed block into the DMA channel;

reading the first compressed block into the DMA channel; and

reading one or more subsequent compressed blocks linked to the first compressed block into the DMA channel.

27. (Original) The method of claim 25, wherein said writing the decompressed page to the physical memory is performed by the DMA channel, and wherein said writing the decompressed page to the physical memory comprises the DMA channel reading the uncompressed page from the decompression engine.

28. (Original) The method of claim 22, wherein the page comprises one or more compressed blocks, and wherein said providing the page to the decompression engine comprises: a plurality of Direct Memory Access (DMA) channels reading the one or more compressed blocks; and the plurality of DMA channels copying the one or more compressed blocks to the decompression engine.

A₃ 29. (Original) The method of claim 1, further comprising: providing a different portion of the compressed page to each of a plurality of decompression engines; and each of the plurality of decompression engines decompressing the portion of the compressed page provided to the particular decompression engine.

30. (Original) The method of claim 29, wherein each of the plurality of decompression engines implements a data decompression algorithm, wherein the data decompression algorithm is substantially the same for each of the plurality of decompression engines.

31. (Original) The method of claim 29, wherein the plurality of decompression engines decompresses the portions of the compressed page in parallel.

32. (Original) The method of claim 29, further comprising combining the decompressed portions of the page to produce the decompressed page.

33. (Original) The method of claim 1, wherein said writing the decompressed page to the physical memory comprises: locating a currently unused page in the physical memory in a list of currently unused pages for receiving uncompressed pages; and writing the decompressed page as an uncompressed page to the located currently unused page.

34. (Original) The method of claim 1, wherein the compression of pages of the memory in the system is operable to increase the effective size of the system memory by keeping least recently used data as compressed data in the physical memory and most recently and frequently used data as uncompressed data in the physical memory.

35. (Original) The method of claim 34, wherein the system further comprises an operating system, wherein the operating system is aware of the increased effective size of the system memory.

36. (Original) The method of claim 34, wherein the system further comprises an operating system, wherein the operating system is not aware of the increased effective size of the system memory.

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37. (Original) The method of claim 34, wherein the system further comprises an operating system, wherein the operating system is aware of the increased effective size of a first portion of the system memory, and wherein the operating system is not aware of the increased effective size of a second portion of the system memory.

38. (Original) The method of claim 1, wherein said decompressing the compressed page to produce the decompressed page comprises:

examining the page translation entry to determine if the page translation entry indicates the page is highly compressed, wherein, during compression of the page to generate the highly compressed page, the physical memory occupied by the page is freed for use by one or more processes executing within the system; and

if said examining determines the page is highly compressed:

allocating a portion of the physical memory for the page; and
writing data stored prior to said compressing the page to the page.

39. (Original) The method of claim 38, wherein the page translation entry includes a highly compressed attribute field, wherein the highly compressed attribute field indicates if the page is highly compressed, wherein said examining the page translation entry to determine if the page is highly compressed comprises examining the highly compressed attribute field.

40. (Original) The method of claim 39, wherein the highly compressed attribute field is a one-bit field.

41. (Original) A method for managing compression of pages of memory in a system comprising an operating system and physical memory, wherein the physical memory comprises system memory, the method comprising:

locating a page translation entry in a page translation table, wherein the page translation entry references an uncompressed page in the physical memory;

determining if the uncompressed page is to be compressed;

if said determining indicates the page is to be compressed:

compressing the uncompressed page to produce a compressed page; and

writing the compressed page to the physical memory.

wherein the compression of pages of the memory in the system is operable to increase the effective size of the system memory by keeping least recently used data as compressed data in the physical memory and most recently and frequently used data as uncompressed data in the physical memory; and

wherein the operating system is not aware of the increased effective size of the system memory.

42. (Original) The method of claim 41, wherein said compressing the uncompressed page comprises:

providing the uncompressed page to a compression engine; and

the compression engine compressing the page to produce the compressed page.

43. (Original) The method of claim 42, wherein said providing the page to the compression engine comprises:

one or more Direct Memory Access (DMA) channels reading the uncompressed page from the physical memory; and

the one or more DMA channels writing the uncompressed page to the compression engine.

44. (Original) The method of claim 42, wherein said writing the compressed page to the physical memory comprises:

one or more Direct Memory Access (DMA) channels reading the compressed page from the compression engine; and

the one or more DMA channels copying the compressed page into one or more linked compressed blocks in the physical memory.

45. (Original) The method of claim 44, further comprising locating the one or more linked compressed blocks for storing the compressed page in a list of available compressed blocks for storing compressed pages.

46. (Original) The method of claim 41, wherein said compressing the uncompressed page comprises:

providing a different portion of the uncompressed page to each of a plurality of compression engines; and

the plurality of compression engines each compressing the portion of the page which the particular compression engine was provided; and

combining the compressed portions of the page to produce the compressed page.

47. (Original) The method of claim 46, wherein the plurality of compression engines compress the portions of the compressed page in parallel.

48. (Original) The method of claim 41, wherein said compressing the uncompressed page comprises:

providing the uncompressed page to a plurality of compression engines, wherein each of the plurality of compression engines implements a different compression algorithm;

the plurality of compression engines each compressing the uncompressed page using the compression algorithm implemented by the particular compression engine to produce a plurality of compressed pages each compressed by a different compression algorithm;

selecting the compressed page from the plurality of compressed pages, wherein the selected compressed page has the highest compression ratio of the plurality of compressed pages.

49. (Original) The method of claim 48, further comprising marking the page translation entry associated with the compressed page to indicate the particular compression algorithm used in said compressing the page.

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50. (Original) A method for compressing memory in a system comprising a plurality of compression engines and a physical memory, wherein the physical memory comprises system memory, the method comprising:

locating a page translation entry in a page translation table, wherein the page translation entry references an uncompressed page in the physical memory;

providing the referenced uncompressed page to the plurality of compression engines, wherein each of the plurality of compression engines implements a different compression algorithm;

the plurality of compression engines each compressing the uncompressed page using the compression algorithm implemented by the particular compression engine to produce a plurality of compressed pages each compressed by a different compression algorithm;

selecting the compressed page with the highest compression ratio of the plurality of compressed pages; and

writing the selected compressed page to the physical memory.

51. (Original) The method of claim 50, further comprising marking the page translation entry associated with the selected compressed page to indicate the particular compression algorithm used in said compressing the page.

52. (Original) The method of claim 50, further comprising:

determining that the compressed page needs to be decompressed:

examining the page translation entry to determine the particular compression algorithm used to compress the page;

selecting a decompression engine from a plurality of decompression engines, wherein the selected decompression engine implements a decompression algorithm for decompressing data compressed using the particular compression algorithm;

providing the page to the selected decompression engine; and

the selected decompression engine decompressing the page using the decompression algorithm to produce the decompressed page.

53. (Original) The method of claim 50, wherein the compression of pages of the memory in the system is operable to increase the effective size of the system memory by keeping least

recently used data as compressed data in the physical memory and most recently and frequently used data as uncompressed data in the physical memory.

54. (Original) The method of claim 53, wherein the system further comprises an operating system, wherein the operating system is not aware of the increased effective size of the system memory.

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55. (Original) A method comprising:
determining a compression ratio for system memory in a system comprising physical memory, wherein the physical memory comprises the system memory;
determining if the compression ratio is below a compression ratio threshold;
if the compression ratio is below the compression ratio threshold:
 locating a page translation entry in a page translation table referencing an uncompressed page in the system memory to be highly compressed;
 setting a highly compressed attribute in the page translation entry to indicate that the page is highly compressed; and
 freeing a first portion of the physical memory allocated to the page in the system memory;
wherein highly compressing the page of the memory in the system is operable to increase the compression ratio for the system memory.

56. (Original) The method of claim 55, wherein the highly compressed attribute is a one-bit field in the page translation entry.

57. (Original) The method of claim 55, further comprising:
receiving a system memory access for the page, wherein the system memory access requires that the page be uncompressed;
locating the page translation entry in the page translation table referencing the page;
determining that the page is highly compressed; and
allocating a second portion of the physical memory for the page.

58. (Original) The method of claim 57, further comprising filling the page with zeros after said allocating.

59. (Original) The method of claim 57, further comprising, after said allocating:
reading data from non-volatile storage; and
writing the data to the page.

60. (Original) The method of claim 55, further comprising, prior to said freeing the
physical memory allocated to the page:
determining if the page is dirty; and
if the page is dirty, writing data from the page to non-volatile storage to make the page clean.

61. (Original) A system comprising:
one or more processors;
a physical memory comprising a system memory;
a system memory controller; and
a compressed memory management unit (CMMU), configured to:
 receive from a first processor of the one or more processors a system memory access
 comprising a system memory address;
 translate the system memory address into a first physical memory address;
 cause the decompression of the compressed data at the first physical memory address
 in the physical memory;
 write the decompressed data to a second physical memory address; and
 pass the second physical memory address to the system memory controller;
 wherein the system memory controller is configured to fulfill the system memory
 access from the decompressed data at the second physical memory address;
 and
 wherein the CMMU is operable to increase the effective size of the system memory by
 keeping least recently used data as compressed data in the physical memory
 and most recently and frequently used data as uncompressed data in the
 physical memory.

62. (Original) The system of claim 61, wherein the system further comprises program
instructions executable within the system to implement an operating system, wherein the operating
system is aware of the increased effective size of the system memory.

63. (Original) The system of claim 61, wherein the system further comprises program instructions executable within the system to implement an operating system, wherein the operating system is not aware of the increased effective size of the system memory.

64. (Original) The system of claim 61, wherein the system further comprises program instructions executable within the system to implement an operating system, wherein the operating system is aware of the increased effective size of a first portion of the system memory, and wherein the operating system is not aware of the increased effective size of a second portion of the system memory.

65. (Original) The system of claim 61, wherein the CMMU comprises:
a page translation cache configured to cache page translation entries; and
one or more scatter/gather Direct Memory Access (DMA) channels configured for
transferring data from the CMMU to one or more destinations and for receiving data
on the CMMU from one or more sources.

66. (Currently Amended) The system of claim ~~17~~65, wherein the CMMU further comprises a compression/decompression engine configured to compress uncompressed data and to decompress compressed data under control of the CMMU.

67. (Original) The system of claim 61, further comprising:
a page translation table comprising one or more page translation entries;
wherein, in said translating the system memory address into a first physical memory address,
the CMMU is further configured to:
locate a page translation entry for the system memory address in the page translation
table; and
determine the first physical memory address from the page translation entry for the
system memory address.

68. (Original) The system of claim 67, wherein the CMMU further comprises:
a page translation cache comprising one or more cached page translation entries from the page
translation table;

wherein, in said locating a page translation entry, the CMMU is further configured to search for the page translation entry associated with the system memory address in the page translation cache;

wherein, if said searching the page translation cache locates the page translation entry in the page translation cache, the page translation entry from the page translation cache is used in said determining the first physical memory address.

69. (Original) The system of claim 68, wherein, if said searching the page translation cache does not locate the page translation entry in the page translation cache, the CMMU is further configured to:

search for the page translation entry in the page translation table;

wherein, if said searching the page translation table locates the page translation entry in the page translation table, the page translation entry from the page translation table is used in said determining the first physical memory address.

70. (Original) The system of claim 69, wherein the CMMU is further configured to cache the page translation entry located in the page translation table to the page translation cache as a recently used page translation entry.

71. (Original) The system of claim 68, wherein the page translation cache is fully associative.

72. (Original) The system of claim 71, wherein, in said searching for the page translation entry associated with the system memory address in the page translation cache, the CMMU is further configured to compare the system memory address with all page translation entries in the page translation cache in parallel.

73. (Original) The system of claim 61, wherein the system further comprises:
a compression/decompression engine;

wherein, in said causing the decompression of the compressed data, the CMMU is further configured to write the compressed data to the compression/decompression engine;
and

wherein the compression/decompression engine is configured to decompress the compressed data to produce the decompressed data.

74. (Original) The system of claim 73, wherein the CMMU further comprises:
one or more Direct Memory Access (DMA) channels;
wherein the compressed data comprises one or more compressed blocks, and wherein, in said
writing the compressed data to the compression/decompression engine, the one or
more DMA channels are configured to:
read the one or more compressed blocks; and
copy the one or more compressed blocks to the compression/decompression engine.

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75. (Original) The system of claim 74, wherein the CMMU is further configured to:
load a physical memory address of a first compressed block into the one or more DMA
channels; and
wherein in reading the one or more compressed blocks, the one or more DMA channels are
further configured to read the first compressed block and one or more subsequent
compressed blocks linked to the first compressed block.

76. (Original) The system of claim 74, wherein said writing the decompressed data to the
second physical memory address is performed by the one or more DMA channels, and wherein, in
said writing the decompressed data to the second physical memory address, the one or more DMA
channels are further configured to read the decompressed data from the compression/decompression
engine.

77. (Original) The system of claim 61, wherein the system further comprises a plurality of
compression/decompression engines, wherein at least two of the plurality of
compression/decompression engines implement different compression/decompression algorithms,
and wherein the CMMU is further configured to:

prior to said writing the compressed data to the compression/decompression engine:
determine a particular compression algorithm used to compress the compressed data;
and
select the compression/decompression engine from the plurality of
compression/decompression engines, wherein the selected
compression/decompression engine is configured to decompress data
compressed using the particular compression algorithm.

78. (Original) The system of claim 61, wherein the system further comprises:
a compression/decompression engine configured to decompress compressed data under
control of the CMMU.

79. (Original) The system of claim 78, wherein the compression/decompression engine is
a parallel compression/decompression engine configured to perform parallel data decompression
under control of the CMMU.

A₃ 80. (Original) The system of claim 78, wherein the compression/decompression engine is
comprised in the CMMU.

81. (Original) The system of claim 61, wherein the CMMU is comprised in one of the one
or more processors.

82. (Original) The system of claim 81, wherein at least one of the one or more processors
further comprises a compression/decompression engine configured to decompress compressed data
under control of the CMMU.

83. (Original) The system of claim 81, wherein the system memory controller comprises
a compression/decompression engine configured to decompress compressed data under control of the
CMMU.

84. (Original) The system of claim 81, wherein the physical memory comprises one or
more memory modules, and wherein at least one of the one or more memory modules comprises a
compression/decompression engine configured to decompress compressed data under control of the
CMMU.

85. (Original) The system of claim 61, wherein the CMMU is comprised in the system
memory controller.

86. (Original) The system of claim 85, wherein the system memory controller further
comprises a compression/decompression engine configured to decompress compressed data under
control of the CMMU.

87. (Original) The system of claim 85, wherein the physical memory comprises one or more memory modules, and wherein at least one of the one or more memory modules comprises a compression/decompression engine configured to decompress compressed data under control of the CMMU.

88. (Original) The system of claim 61, wherein the physical memory comprises one or more memory modules, wherein the CMMU is coupled to the system memory controller and the one or more memory modules.

A3 89. (Original) The system of claim 88, wherein at least one of the one or more memory modules comprises a compression/decompression engine configured to decompress compressed data under control of the CMMU.

90. (Original) The system of claim 61, wherein the system further comprises:
a plurality of compression/decompression engines;
wherein, in said causing the decompression of the compressed data, the CMMU is further configured to write a different portion of the compressed data to each of the plurality of compression/decompression engines;
wherein the plurality of compression/decompression engines are configured to decompress the portions of the compressed data to produce a plurality of decompressed data portions; and
wherein the CMMU is further configured to combine the plurality of decompressed data portions to produce the decompressed data.

91. (Original) The system of claim 90, wherein each of the plurality of compression/decompression engines implements a data decompression algorithm, wherein the data decompression algorithm is substantially the same for each of the plurality of compression/decompression engines.

92. (Original) The system of claim 90, wherein the plurality of compression/decompression engines decompress the portions of the compressed data in parallel.

93. (Original) The system of claim 61, wherein, in said writing the decompressed data to physical memory, the CMMU is further configured to:

locate a currently unused page in the physical memory in a list of currently unused pages for receiving uncompressed data; and

write the decompressed data as an uncompressed page to the located currently unused page.

94. (Original) The system of claim 61, wherein the CMMU is further configured to manage the system memory on a page granularity.

95. (Original) The system of claim 61, wherein page size is programmable.

96. (Original) The system of claim 61, wherein a maximum compression ratio applied by the CMMU is programmable.

97. (Original) The system of claim 61, further comprising a kernel driver configured to: monitor an actual compression ratio achieved by the CMMU; and ensure that a minimum compression ratio is maintained by the CMMU.

98. (Original) A system comprising:

one or more processors;

a system memory controller;

a physical memory comprising a system memory; and

a compressed memory management unit (CMMU), configured to:

translate a system memory address into a first physical memory address;

cause the compression of the uncompressed data at the first physical memory address to produce compressed data; and

write the compressed data to a second physical memory address;

wherein the system is operable to increase the effective size of system memory by keeping least recently used pages compressed in the physical memory and most recently and frequently used pages uncompressed in the physical memory.

99. (Original) The system of claim 98, wherein the system further comprises program instructions executable within the system to implement an operating system, wherein the operating system is aware of the increased effective size of the system memory.

100. (Original) The system of claim 98, wherein the system further comprises program instructions executable within the system to implement an operating system, wherein the operating system is not aware of the increased effective size of the system memory.

A₃ 101. (Original) The system of claim 98, wherein the system further comprises program instructions executable within the system to implement an operating system, wherein the operating system is aware of the increased effective size of a first portion of the system memory, and wherein the operating system is not aware of the increased effective size of a second portion of the system memory.

102. (Original) The system of claim 98, further comprising:
wherein the CMMU is further configured to receive from a first processor of the one or more processors the system memory access comprising a system memory address.

103. (Original) The system of claim 98, wherein the CMMU comprises:
a page translation cache configured to cache page translation entries; and
one or more scatter/gather Direct Memory Access (DMA) channels configured for
transferring data from the CMMU to one or more destinations and for receiving data
on the CMMU from one or more sources.

104. (Original) The system of claim 103, wherein the CMMU further comprises a
compression/decompression engine configured to compress uncompressed data and to decompress
compressed data under control of the CMMU.

105. (Original) The system of claim 103, wherein the page translation cache is fully
associative.

106. (Original) The system of claim 98, wherein the system further comprises:
a compression/decompression engine configured to compress uncompressed data under
control of the CMMU.

107. (Original) The system of claim 106, wherein the compression/decompression engine
is a parallel compression/decompression engine configured to perform parallel data compression
under control of the CMMU.

108. (Original) The system of claim 106, wherein the compression/decompression engine
is comprised in the CMMU.

A3 109. (Original) The system of claim 98, wherein the CMMU is comprised in one of the one
or more processors.

110. (Original) The system of claim 109, wherein at least one of the one or more
processors comprises a compression/decompression engine configured to compress uncompressed
data under control of the CMMU.

111. (Original) The system of claim 109, wherein the system memory controller comprises
a compression/decompression engine configured to compress uncompressed data under control of the
CMMU.

112. (Original) The system of claim 109, wherein the physical memory comprises one or
more memory modules, and wherein the at least one of the one or more memory modules comprises a
compression/decompression engine configured to compress uncompressed data under control of the
CMMU.

113. (Original) The system of claim 98, wherein the CMMU is comprised in the system
memory controller.

114. (Original) The system of claim 113, wherein the system memory controller further
comprises a compression/decompression engine configured to compress uncompressed data under
control of the CMMU.

115. (Original) The system of claim 113, wherein the physical memory comprises one or more memory modules, and wherein at least one of the one or more memory modules comprises a compression/decompression engine configured to compress uncompressed data under control of the CMMU.

116. (Original) The system of claim 98, wherein the physical memory comprises one or more memory modules, wherein the CMMU is coupled to the system memory controller and the one or more memory modules.

A₃ 117. (Original) The system of claim 116, wherein at least one of the one or more memory modules comprises a compression/decompression engine configured to compress uncompressed data under control of the CMMU.

118. (Original) The system of claim 98, wherein the system further comprises:
a plurality of compression/decompression engines;
wherein, in said causing the compression of the uncompressed data, the CMMU is further configured to write a different portion of the uncompressed data to each of the plurality of compression/decompression engines;
wherein the plurality of compression/decompression engines are configured to compress the portions of the uncompressed data to produce a plurality of compressed data portions;
and
wherein the CMMU is further configured to combine the plurality of compressed data portions to produce the compressed data.

119. (Original) The system of claim 118, wherein each of the plurality of compression/decompression engines implements a data compression algorithm, wherein the data compression algorithm is substantially the same for each of the plurality of compression/decompression engines.

120. (Original) The system of claim 118, wherein the plurality of compression/decompression engines is configured to compress the portions of the uncompressed data in parallel.

121. (Original) The system of claim 98, wherein the system further comprises:
a plurality of compression/decompression engines, wherein each of the plurality of
compression/decompression engines implements a different compression algorithm;
wherein, in said causing the compression of the uncompressed data, the CMMU is further
configured to provide the uncompressed data to each of the plurality of
compression/decompression engines;
wherein the plurality of compression engines are configured to each compress the
uncompressed data using the compression algorithm implemented by the particular
compression engine to produce a plurality of compressed data each compressed by a
different compression algorithm; and
wherein, in said causing the compression of the uncompressed data, the CMMU is further
configured to select the compressed data from among the plurality of compressed data.

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122. (Original) The system of claim 121, wherein the CMMU selects the compressed data
with the highest compression ratio from among the plurality of compressed data.

123. (Original) The system of claim 121, wherein the system further comprises a page
translation table comprising one or more page translation entries, wherein one of the one or more
page translation entries references a page of physical memory at the second physical memory
address, wherein the CMMU is further configured to mark the page translation entry to indicate the
particular compression algorithm used in said compressing the uncompressed data.

124. (Original) The system of claim 121, wherein the plurality of
compression/decompression engines is configured to compress the uncompressed data in parallel.

125. (Original) The system of claim 98, further comprising:
a compression/decompression engine;
wherein, in said causing the compression of the uncompressed data, the CMMU is further
configured to write the uncompressed data to the compression/decompression engine;
and
wherein the compression engine is configured to compress the uncompressed data to produce
the compressed data.

126. (Original) The system of claim 125, wherein the CMMU further comprises:
one or more Direct Memory Access (DMA) channels;
wherein, in said writing the uncompressed data to the compression/decompression engine, the
one or more DMA channels are configured to:
read the uncompressed data from physical memory; and
write the uncompressed data to the compression/decompression engine.

127. (Original) The system of claim 125, wherein, in said writing the compressed data to
the second physical memory address, the one or more DMA channels are further configured to:
read the compressed page from the compression/decompression engine; and
copy the compressed data into one or more linked compressed blocks in physical memory.

A₃ 128. (Original) The system of claim 125, wherein the CMMU is further configured to:
locate the one or more compressed blocks for storing the compressed data in a list of available
compressed blocks for storing compressed data; and
link the one or more compressed blocks to generate the one or more linked compressed
blocks.

129. (Original) A system comprising:
one or more processors;
a system memory controller;
a physical memory comprising a system memory; and
a compressed memory management unit (CMMU), configured to:
maintain a threshold compression ratio, wherein the threshold compression ratio is a
desired minimum ratio between compressed pages and uncompressed pages of
the system memory;
dynamically monitor a current compression ratio for the system memory, wherein the
current compression ratio is an actual ratio between compressed pages and
uncompressed pages of the system memory, and wherein the compression ratio
determines an amount by which system memory address space can be
increased;
dynamically determine if the current compression ratio is below the threshold
compression ratio;

if the current compression ratio is below the threshold compression ratio, cause the compression of one or more uncompressed pages to generate one or more compressed pages; and
wherein the CMMU is operable to increase the effective size of the system memory by keeping least recently used pages compressed in the physical memory and most recently and frequently used pages uncompressed in the physical memory; and
wherein compressing the one or more uncompressed page is operable to increase the current compression ratio for the system memory.

130. (Original) The system of claim 129, wherein the threshold compression ratio is programmable to determine an amount by which the effective size of the system memory can be increased.

A₃
131. (Original) The system of claim 129, further comprising:
a compression engine;
wherein, in said causing the compression of the one or more uncompressed pages, the CMMU is further configured to write the uncompressed pages to the compression engine; and
wherein the compression engine is configured to compress the one or more uncompressed pages to produce the one or more compressed pages.

132. (Original) The system of claim 129, wherein, in said causing the compression of the one or more uncompressed pages, the CMMU is further configured to:
locate a page translation entry in a page translation table referencing an uncompressed page in the system memory;
determine that the uncompressed page is highly compressible;
set a highly compressed attribute in the page translation entry to indicate that the page is highly compressed; and
free a portion of the physical memory allocated to the page in the system memory;
wherein highly compressing the uncompressed page is operable to increase the current compression ratio for the system memory.

133. (Original) The system of claim 132, wherein the highly compressed attribute is a one-bit field in the page translation entry.

134. (Original) The system of claim 129, wherein the CMMU is further configured to, prior to said freeing the portion of the physical memory allocated to the page:

determine if the page is dirty; and

if the page is dirty, write data from the page to non-volatile storage to make the page clean.

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